Sample Selection and Bright Star Masking in the DELVE Survey

Yueling Kathryn Xu
Supervisor: Javier Sánchez
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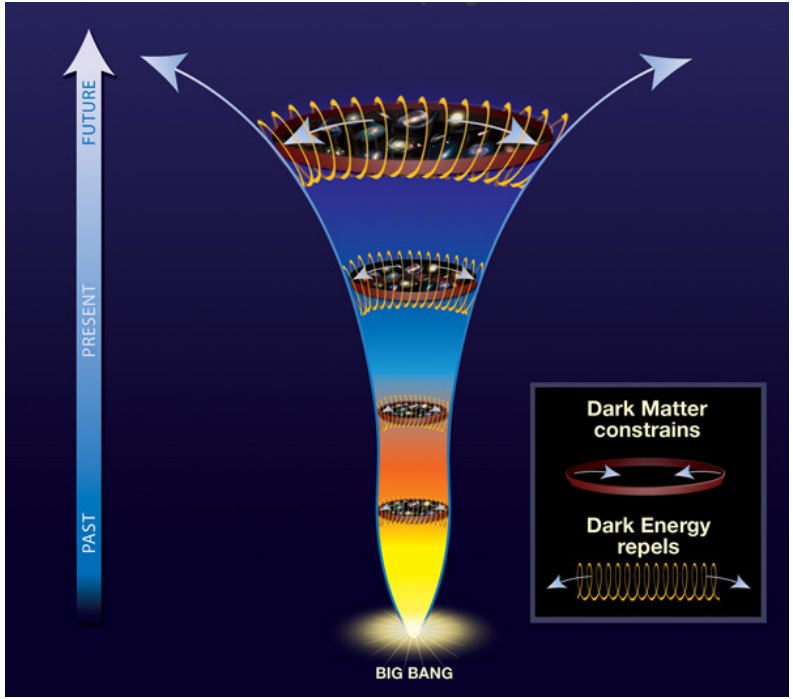
Background: Dark Energy and Dark Matter

- Push-pull between dark matter vs. dark energy
- Λ: the cosmological constant
- Ways of observing dark energy:
  - Cosmic microwave background (CMB) experiments
  - Gravitational wave experiments
  - Galaxy surveys:
    - Baryonic acoustic oscillations (BAO)
    - 2-point correlation functions



Chandra X-Ray Observatory

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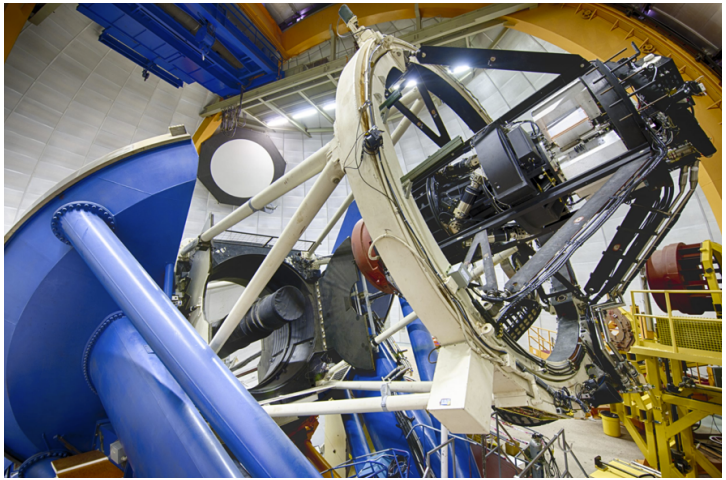
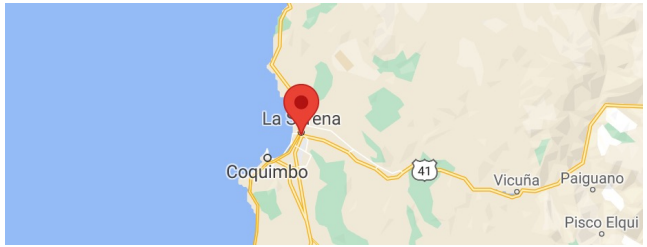
Background: DELVE (DECam Local Volume Explorer)





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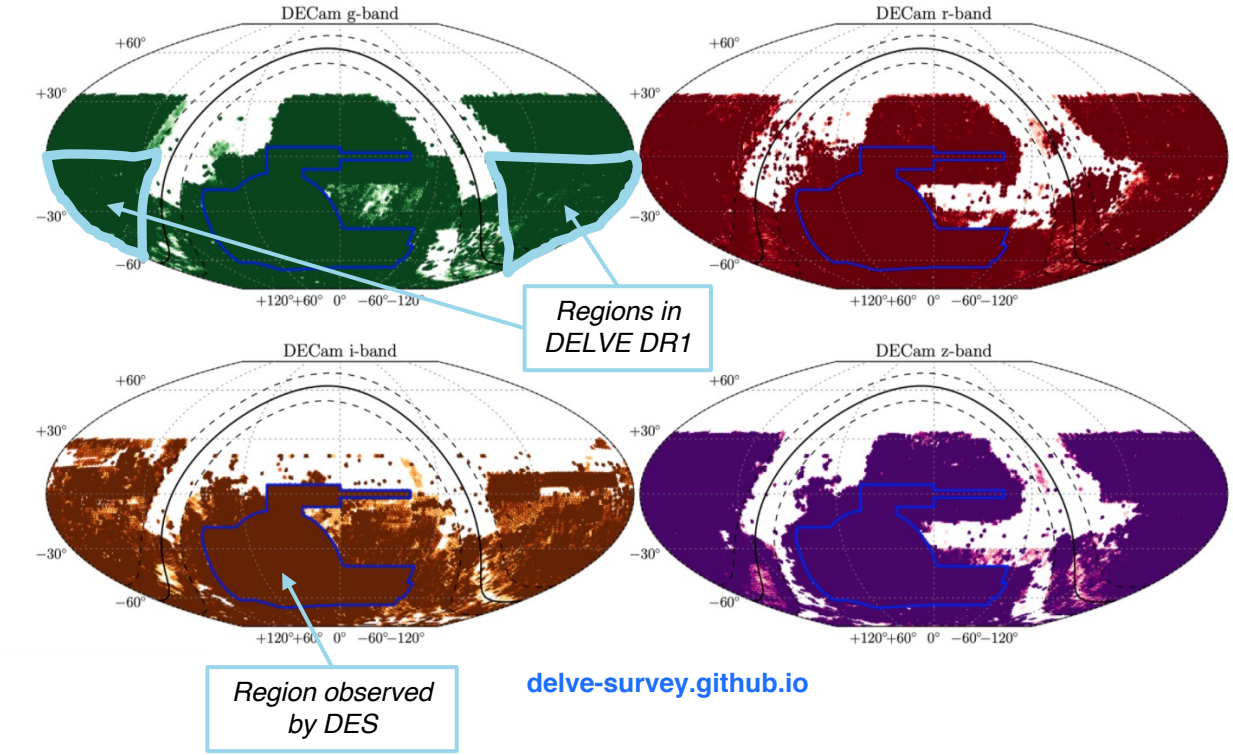
Background: DELVE Coverage



delve-survey.github.io

- Information in four broad filters: **g**, **r**, **i**, **z**
- Calculate accurate redshifts (z) to find distances
- Compute 2-point correlation functions

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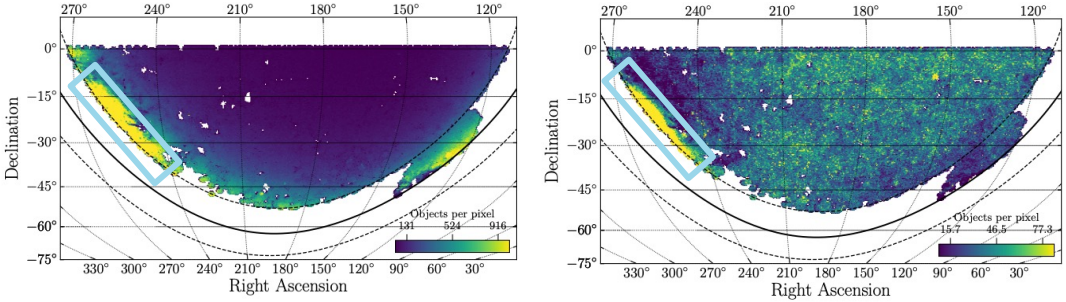
Sample Selection: Issues

1. Not every object has a valid magnitude

**note: larger values of magnitude = dimmer objects

spread_model_g	spreaderr_model_g	mag_auto_g	quick_object_id
-1.000000	1.000000	99.000000	10830000223120
...	...	...	...
-0.000003	0.001547	22.387672	10715000018024
-1.000000	1.000000	99.000000	10715000097707
0.001384	0.002553	22.956795	10715000089127



A. Drlica-Wagner et al. 2021

2. Some areas have heavy levels of stellar contamination

3. Occasionally difficult to distinguish between galaxies and stars, especially at dimmer magnitudes

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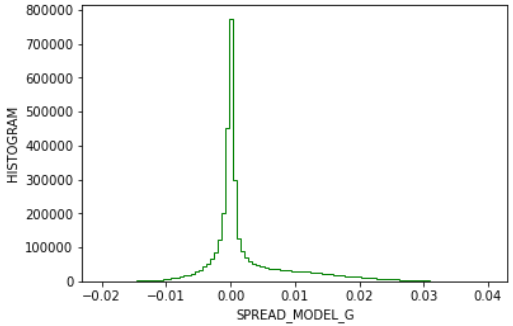
Sample Selection: EXTENDED_CLASS_G

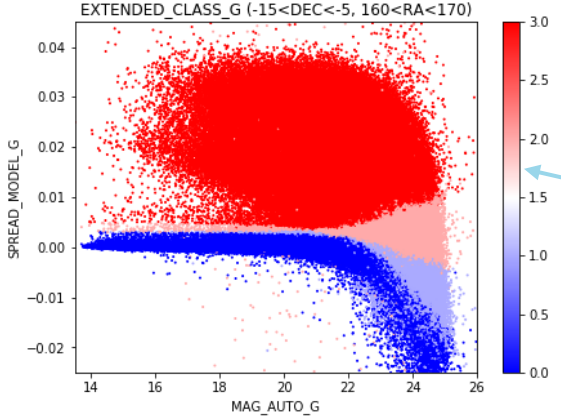
- EXTENDED_CLASS_G is defined as:

```
((SPREAD_MODEL_G + 3 *
SPREADERR_MODEL_G) > 0.005) +
((SPREAD_MODEL_G +
SPREADERR_MODEL_G) > 0.003) +
((SPREAD_MODEL_G -
SPREADERR_MODEL_G) > 0.003)
```

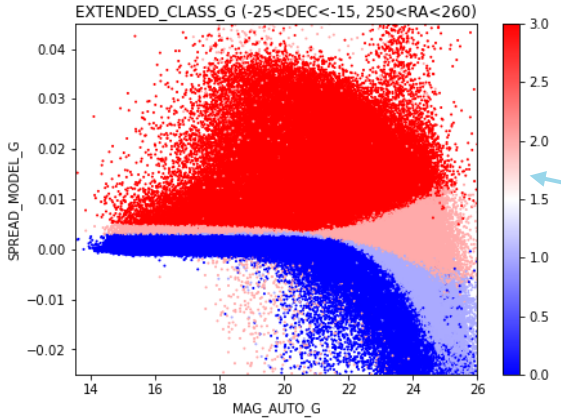
A. Drlica-Wagner et al. 2021

- Values from 0 (high-confidence star) to 3 (high-confidence galaxy)





From area of normal contamination



From area of high contamination

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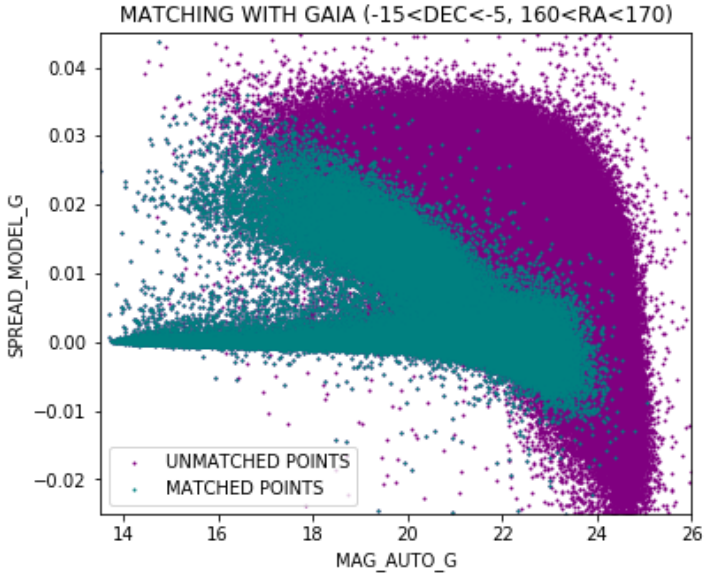
Sample Selection: Matching with Gaia

- Gaia Catalog: archive primarily focused on giving position and brightness of stars
  - 1.20 billion objects in GDR2—only 2.3 million are quasars and 0.37 million are galaxies

    Bailer-Jones, Fouesneau and Andrae 2019
- Matching:
  - Manually using `skycoord` from `astropy.coordinates`
  - Provided matches in GDR3

	id1	ra1	dec1	id2	ra2	dec2	distance
0	3038043849816265600	120.000001	-10.801280	10727500028295	119.999995	-10.801283	6.013239e-06
1	3036449519295960960	120.000003	-11.579927	10740200005175	120.000008	-11.579913	1.473089e-05
2	3036260953053072768	120.000017	-11.653540	10740200005170	120.000015	-11.653539	2.803247e-06
3	3038043815456539776	120.000030	-10.817037	10727500028298	120.000021	-10.817041	1.014988e-05



From area of normal contamination

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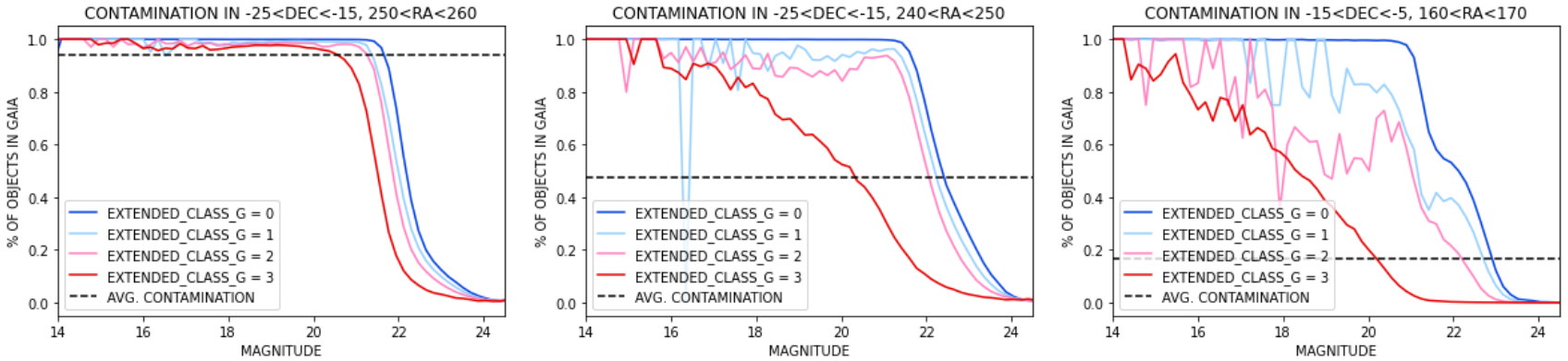
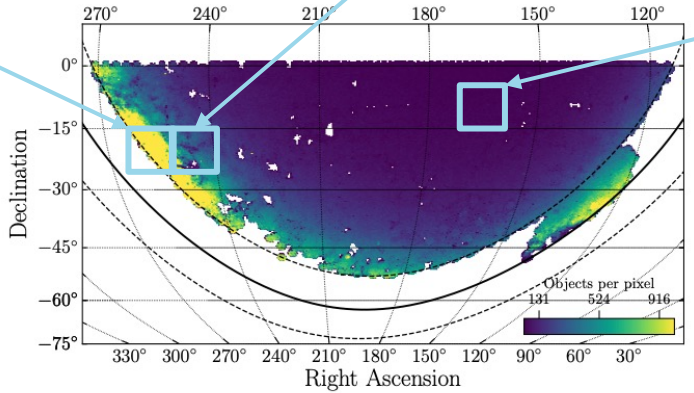
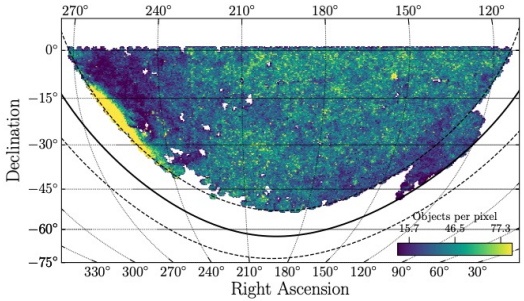
Sample Selection: Levels of Stellar Contamination







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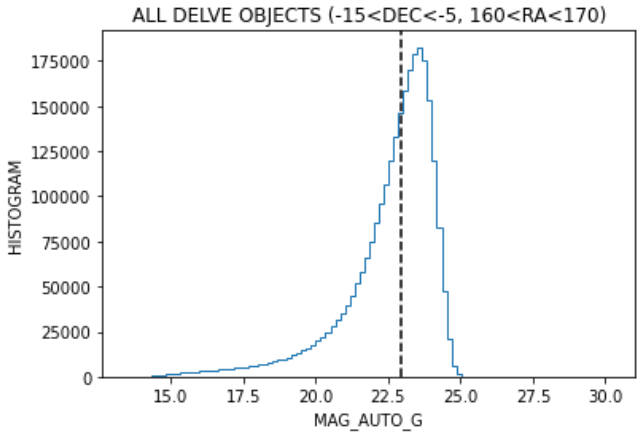
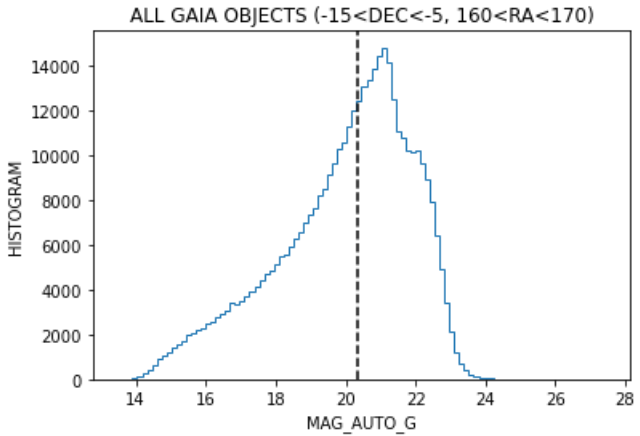
Sample Selection: Notes on Gaia and Matching

- Compared to DELVE, Gaia is less deep
- Subaru Hyper Suprime-Cam
- Limitations in object separation and distinction in DELVE





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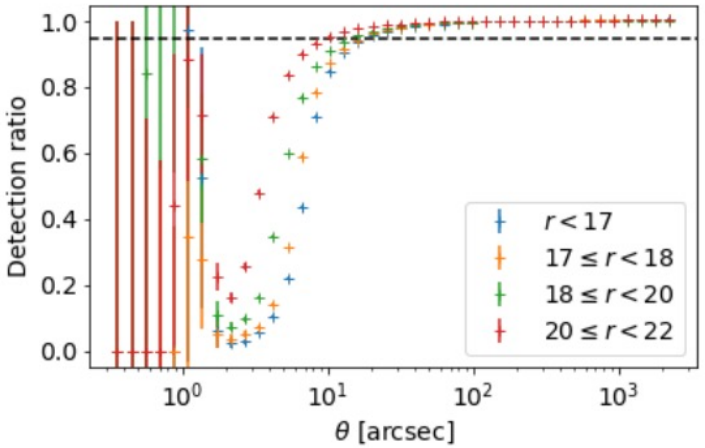
Bright Star Masking: Issues

- Determine detection ratio around stars as a function of radius and magnitude
- KDTrees and querying

- Methods:
  - 1. detection ratios compared to a random point/ around all stars
  - 2. relative density compared to a radius of 20 arcsecs



1 J. Sánchez et al. 2020

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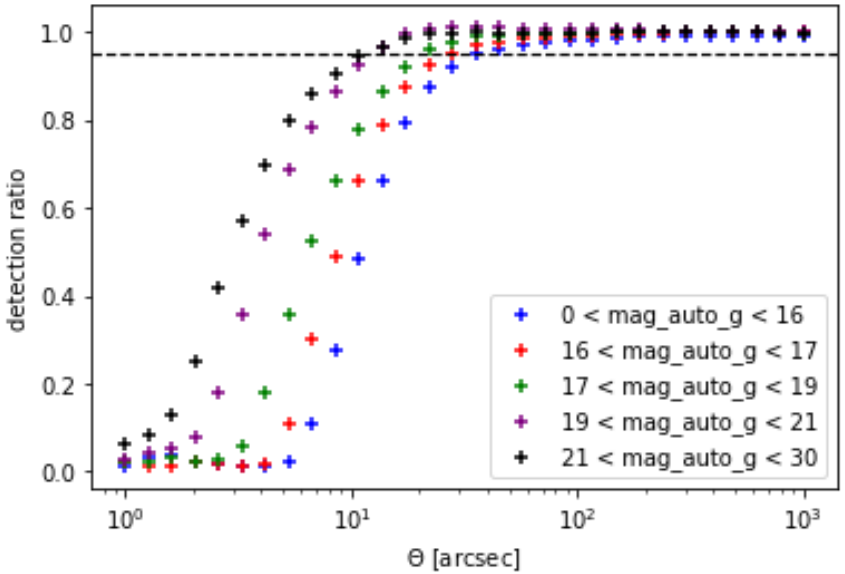
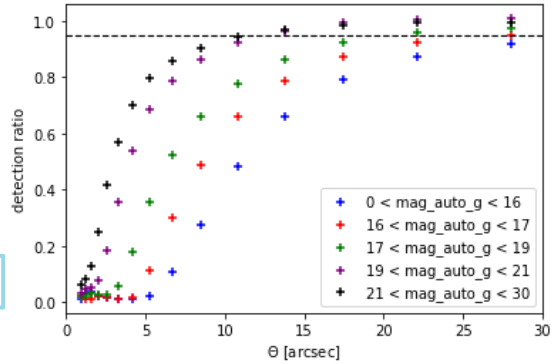
Bright Star Masking: Detection Ratios by Magnitude

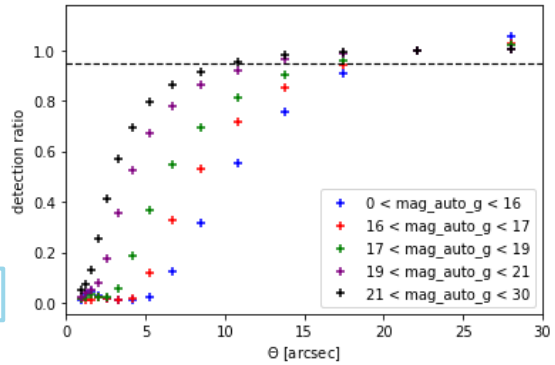


Detection ratio as a function of radius and magnitude

1



2



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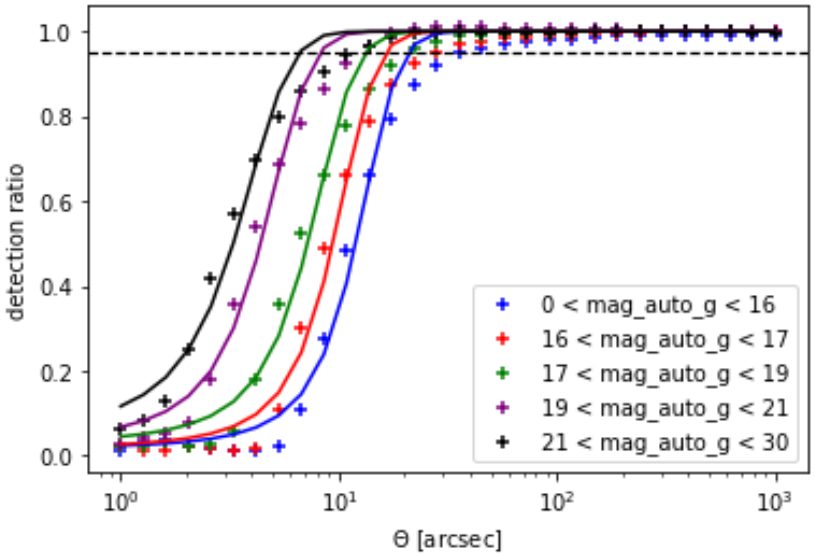
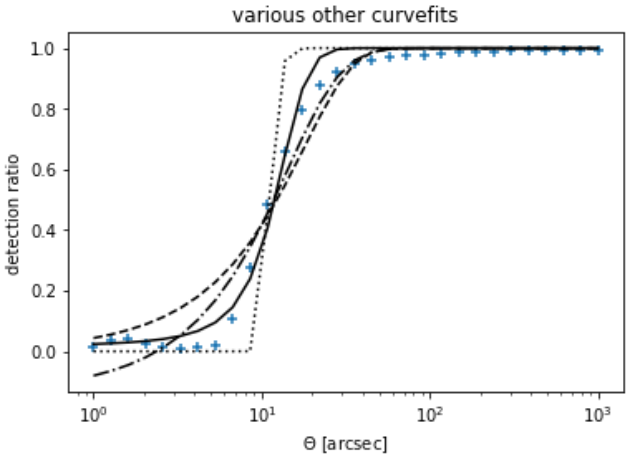
Bright Star Masking: Determining Masking Radii — Curve Fit



$$\frac{1}{1+be^{-x/r}}$$



— : $\frac{1}{1+be^{-x/r}}$

– – : scipy.special.erf(x/r)

– . : $\tan^{-1}(\frac{x}{r}+b)$

. . : $(1+e^{-x})^{-r}$

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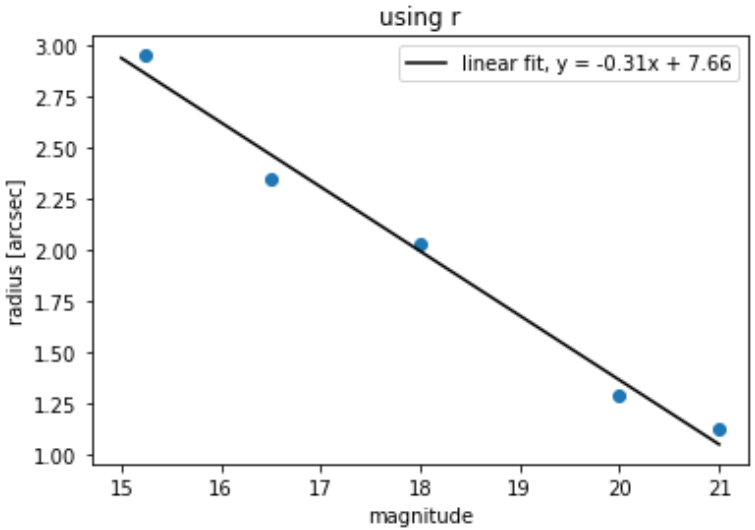
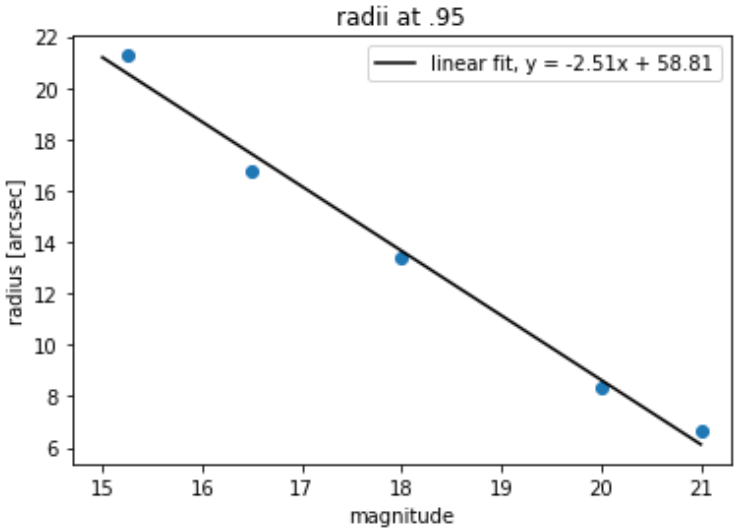
Bright Star Masking: Determining Masking Radii — Linear





- Use value of *r* in $\frac{1}{1+be^{-x/r}}$ vs. use the value where fitted curve = .95
- `scipy.interpolate`

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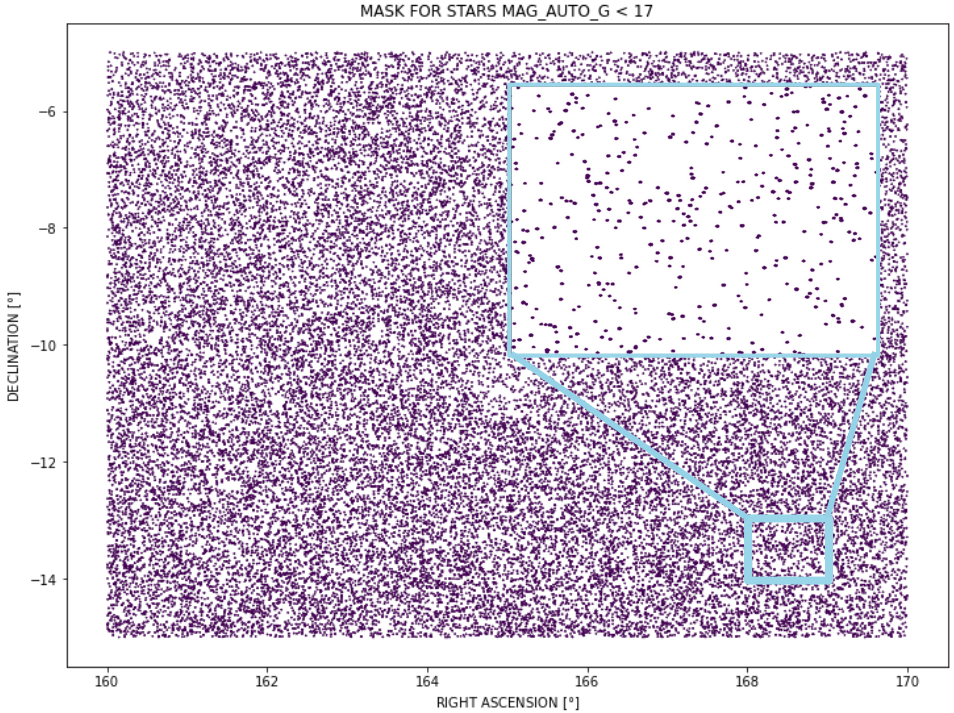
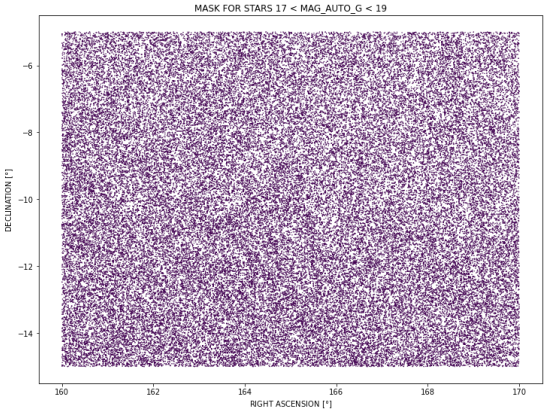
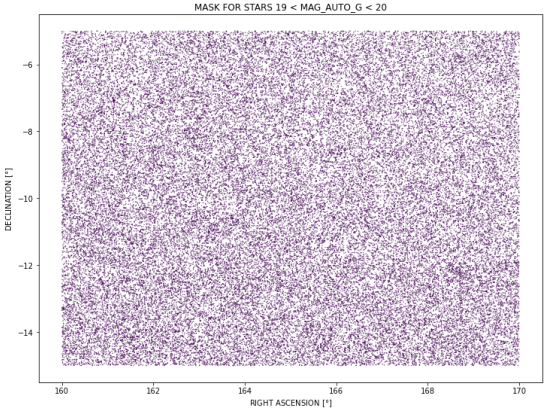
Bright Star Masking: Generating `Healsparse` Maps

- `healsparse`: package to generate high resolution `healpy` maps







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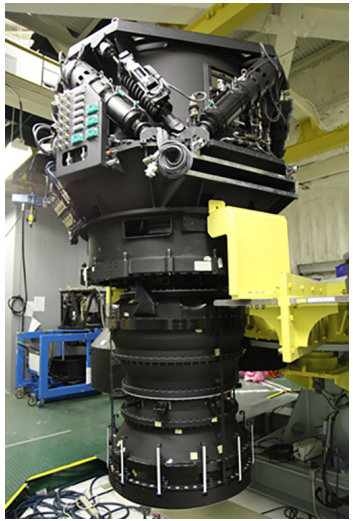
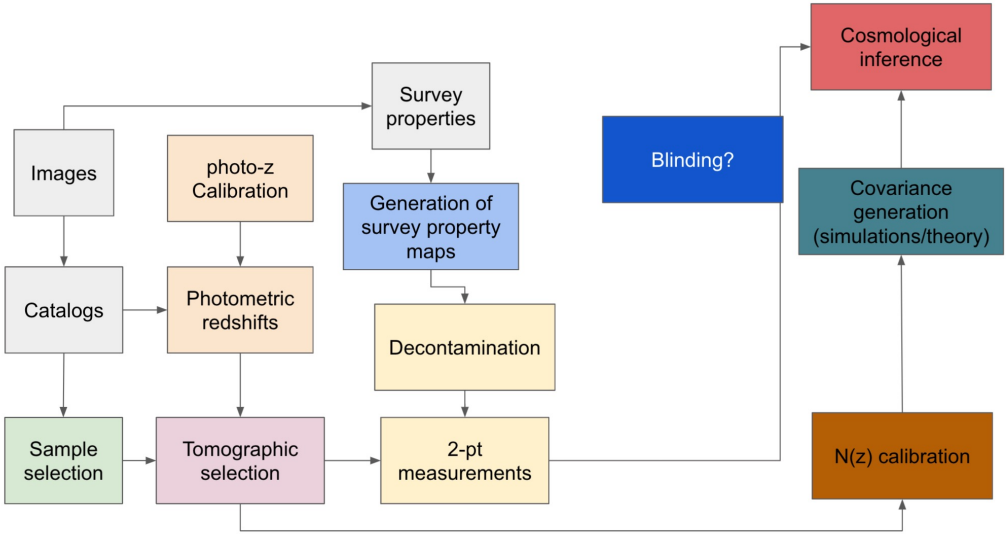
Next Steps

- Expanding to the entirety of the area covered by DELVE (no more memory issues!)
- Comparison to HSC data



Subaru Hyper Suprime-Cam

subarutelescope.org



DELVE LSS project workflow

J. Sánchez — private comm.

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References

A. Drlica-Wagner et al. (DELVE Collaboration), arXiv:2103.07476 (2021)

C. Bailer-Jones, M. Fouesneau, R. Andrae, arXiv:1910.05255 (2019)

J. Sánchez et al. (LSST DESC Collaboration), arXiv:2001.00941 (2020)

Acknowledgments

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Questions?